REMARKS/ARGUMENTS

Claims 1-5 are pending in the Application. By this Amendment, claims 2-5 are being amended to improve their form. No new matter is involved.

In Paragraph 3 which begins on page 2 of the Office Action, claims 4, 1-3 and 5 are rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent 6,458,202 of Kojima et al. in view of Ito JP01040668. This rejection is respectfully traversed, and is discussed hereafter.

In Paragraphs 5, 6, 7 and 8 which appear on pages 6 and 7 of the Office Action, claims 2, 3, 4 and 5 are said to contain expressions which are indefinite. In response to these rejections, Applicant is amending claims 2-5 to either eliminate or rewrite the objectionable phrases, in order to make claims 2-5 definite.

As amended herein, claim 2 now recites "so that temperature gradient of the single crystal surface along the pulling axis direction is constant". The objectionable expression "should be constant irrespective of the weight ratio of the growing crystal relative to the weight of raw material melt before the growing" has been eliminated.

In the case of claim 3, such claim as amended herein recites "the subsidiary heating means are controlled to approach the target value or values during the pulling of the single crystal". As so amended, the objectionable phrase "are controlled to be as near the target value or values as possible" has been eliminated.

In the case of claim 4, the limitation "a crucible having an inner diameter of 28 inches or more is used" has been added, the objectionable phrase "so that the raw material melt should not be solidified" has been replaced by "to prevent solidification of raw material melt", and the objectionable phrase "according to the introduction of the raw material" has been replaced by "when the raw material is newly added to the raw material melt remaining in the crucible". The limitation

defining the crucible inner diameter of 28 inches or more corresponds to the description at line 17 of page 13 through line 6 of page 14, lines 7 and 8 of page 22, and elsewhere throughout the specification. The added language "to prevent solidification of raw material melt" is described at lines 16-21 of page 6 of the specification, at lines 21-24 of page 12, and elsewhere throughout the specification.

As amended herein, claims 2-5 should now be clear and definite.

As noted above, claims 4, 1-3 and 5 have been rejected as unpatentable over Kojima in view of Ito. This rejection is respectfully traversed.

As amended herein, independent claim 4 defines a method for growing a semiconductor single crystal according to the Czochralski method in which a crucible having an inner diameter of 28 inches or more is used, and in the case that so-called multi-pulling is performed, the crucible is heated by the heater surrounding the crucible and the subsidiary heating means to prevent solidification of raw material melt at least for a period from the point of the detachment of the single crystal ingot to the point of complete melting of the raw material in the crucible including the raw material newly added thereto and the electric power supplied to the subsidiary heater is increased when the raw material is newly added to the raw material melt remaining in the crucible.

As described at line 18 of page 3 through line 3 of page 4 of the specification, by using a crucible of larger diameter, heating from the lateral direction only by the side heater 2 in an ordinary apparatus for producing a single crystal as shown in Fig. 3 of the application tends to become insufficient in terms of heating quantity. In particular, after the single crystal ingot is detached, the heat receiving area from the lateral direction is decreased because the melt becomes shallow. As a result, it is likely that a phenomenon of solidification of the melt frequently occurs. And, in the multi-pulling, when the raw material is occasionally introduced, a stress is

applied to the crucible at the time of solidification, and the crucible may crack (see line 20 of page 20 through line 5 of page 21 of the specification).

However, in accordance with claim 4 as amended herein, when a single crystal according to the Czochralski method is grown, the multi-pulling is performed by using a large diameter crucible having an inner diameter of 28 inches or more, the crucible is heated by the heater surrounding the crucible and the lower subsidiary heating means for a period from the point of the detachment of the single crystal ingot to the point of complete melting of the raw material in the crucible including the raw material newly added thereto. Further, the electric power supplied to the subsidiary heater is increased when the raw material is newly added thereto. In accordance with this method, the raw material can be introduced at a high introduction rate, and the crucible is prevented from being cracked by solidification of melt and from being deformed by excessively elevated temperature. Moreover, large single crystals can be obtained with a high yield (see line 21 of page 11 through line 19 of page 14, line 6-26 of page 21, and elsewhere throughout the specification).

As set forth in Fig. 1A, Fig. 3, claims 1 and 4, lines 42-51 of column 6, lines 12-14 of column 9 and elsewhere throughout Kojima, such reference discloses that when a silicon ingot is grown by a CZ method, heat is supplied by the side heater and the bottom heater during the second half of the growth process of the ingot. However, Kojima neither teaches nor suggests that the raw material is additionally charged in the crucible after a single crystal is pulled and another single crystal is continuously grown, namely multi-pulling. Therefore, in Kojima, it is unlikely that the electric power supplied to the bottom heater is increased after a grown single crystal is detached from the melt as recited in claim 4 of the present application. Moreover, in the Example of columns 13 and 14, Kojima discloses that a silicon

single crystal having a diameter of 200 mm is grown by using a crucible having a diameter of 22 inches. However, Kojima does not describe or suggest a large diameter crucible having an inner diameter of 28 inches or more as recited in claim 4 as amended herein. This is used, for example, in the case where a silicon single crystal having a diameter of 300 mm or more is grown. Furthermore, Kojima neither teaches nor suggests that the remaining melt is likely to solidify in particular when such a crucible having a large diameter is used.

As described in the Abstract, Figs. 1 and 2, and elsewhere, Ito discloses that the raw materials 6 in a crucible 2 are melted rapidly and effectively by side heaters 3 and bottom heaters 4. However, the reference neither teaches nor suggests multi-pulling. Therefore, in Ito, it is also unlikely that the electric power supplied to the bottom heater is increased after a growing single crystal is detached from the melt. Moreover, as described at lines 9-11 in the upper right column on page 3 of Ito, polycrystal silicon of 50 kg charged in "the inner crucible made of quartz 2a having a diameter of 16 inches" was melted by the side heater 3 and bottom heater 4. However, Ito does not describe a crucible having a large diameter of 28 inches or more, as recited in amended claim 4 of the present application. Moreover, the reference neither teaches nor suggests that the remaining melt is likely to solidify in particular when such a crucible having a large diameter is used.

In the discussion at line 18 of page 3 through line 17 of page 4 of the Office Action, it is asserted that it would have been obvious to one of ordinary skill in the art at the time of the present invention to combine the raw material melting use of the bottom heater (Ito) with the growth use of the bottom heater (Kojima) because the turn-around time between uses of the apparatus would have been reduced and more product could have been made, and that the electric power supplied to the subsidiary heating means be increased when raw material was introduced.

Moreover, as set forth in Paragraph 9 on page 7 of the Office Action, the textbook of Sears et al. is referenced, and it is indicated that solid raw material must be supplied with the heat of fusion in addition to any heat required to raise its temperature if it is to be melted. In lines 1-13 of page 4 of the Office Action, there are descriptions such as "between batch cycles" and the like, and Kojima and Ito are applied to the multi-pulling. However, as described above, Kojima and Ito neither teach nor suggest multi-pulling. Moreover, the Sears textbook only describes a general relationship between a phase change, namely from solid to liquid, for example from ice to water, and heat. Sears has no relationship to multi-pulling of silicon single crystals. Therefore, it is only with the hindsight provided by the present invention that Kojima and Ito are applied to multi-pulling.

Furthermore, even if multi-pulling is performed with the combination of Kojima and Ito, the method of claim 4 as amended herein cannot be derived. As described above, Kojima and Ito neither teach nor suggest that the melt is likely to solidify when a crucible having a large diameter is used, and that a single crystal is grown by using a large diameter crucible having an inner diameter of 28 inches or more as recited in claim 4 as amended herein. Therefore, even if the multi-pulling is performed with the combination of Kojima and Ito, at best, crystals having an ordinary diameter of 200 mm are only grown by using a crucible having a diameter of 22 inches described in the Example of Kojima. Namely it cannot be derived that the multi-pulling is performed by using a large diameter crucible having an inner diameter of 28 inches or more as recited in amended claim 4 of the application.

On the other hand, according to the method of claim 4 as amended, the multi-pulling can be safely and certainly performed using a large diameter crucible having an inner diameter of 28 inches or more and subsidiary heating means (lower

heater), so that large silicon single crystals, for example having a diameter of 300 mm or more, can be produced with high productivity.

As described above, Ito and Kojima neither teach nor suggest that single crystals are grown by multi-pulling and that a silicon single crystal is grown by using a large diameter crucible having an inner diameter of 28 inches or more. Furthermore, Sears has no relationship to the growth of a silicon single crystal at all. Therefore, claim 4 as amended herein cannot be derived from Ito, Kojima and Sears. On the other hand, according to the present invention, the multi-pulling can be safely and efficiently performed by using a large diameter crucible having an inner diameter of 28 inches or more and subsidiary heating means, so that large silicon single crystals can be produced with high productivity.

In conclusion, claims 1-5 are submitted to clearly distinguish patentably over the prior art for the reasons discussed above. Also, claims 2-5 are now submitted to be clear and definite for the reasons set forth above. Therefore, reconsideration and allowance are respectfully requested.

If for any reason the Examiner finds the application other than in condition for allowance, the Examiner is requested to call the undersigned attorney at the Los Angeles, California telephone number (213) 337-6846 to discuss the steps necessary for placing the application in condition for allowance.

If there are any fees due in connection with the filing of this response, please charge the fees to our Deposit Account No. 50-1314.

Respectfully submitted,
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